

Directed-energy weapon

A **directed-energy weapon (DEW)** is a ranged weapon that damages its target with highly focused [energy](#) without a solid projectile, including [lasers](#), [microwaves](#), [particle beams](#), and sound beams. Potential applications of this technology include weapons that target [personnel](#), [missiles](#), vehicles, and optical devices.^{[1][2]}



Police car equipped with an [LRAD-500X](#) sonic weapon (Warsaw, Poland, 2011)

In the United States, [the Pentagon](#), [DARPA](#), the [Air Force Research Laboratory](#), [United States Army Armament Research Development and Engineering Center](#), and the [Naval Research Laboratory](#) are researching directed-energy weapons to counter [ballistic missiles](#), [hypersonic cruise missiles](#), and [hypersonic glide vehicles](#). These systems of missile defense are expected to come online no sooner than the mid to late 2020s.^[3]

China,^{[4][5][6][7]} France,^{[8][9][10][11]} Germany,^{[8][9]} the United Kingdom,^{[12][13]} Russia,^{[14][15][16]} India,^{[17][18][19][20][21]} and Israel^{[22][23][24]} are also developing military-grade directed-energy weapons, while Iran^{[25][26][27][28]} and Turkey claim to have them in active service.^{[29][30][31]} The first use of directed-energy weapons in combat between military forces was claimed to have occurred in Libya in August 2019 by Turkey, which claimed to use the [ALKA directed-energy weapon](#).^[32] After decades of [research and development](#), most directed-energy weapons are still at the experimental stage and it remains to be seen if or when they will be deployed as practical, high-performance military weapons.^{[33][34]}

Operational advantages

Directed energy weapons could have several main advantages over conventional weaponry:

- Directed-energy weapons can be used discreetly; radiation does not generate sound and is invisible if outside the visible spectrum.^{[35][36]}
- Light is, for practical purposes, unaffected by [gravity](#), [windage](#) and [Coriolis force](#), giving it an almost perfectly [flat trajectory](#). This makes aim much more precise and extends the range to line-of-sight, limited only by beam diffraction and spread (which dilute the power and weaken the effect), and absorption or scattering by intervening atmospheric contents.
- Lasers travel at light-speed and have long range, making them suitable for use in [space warfare](#).
- Laser weapons potentially eliminate many logistical problems in terms of ammunition supply, as long as there is enough energy to power them.
- Depending on several operational factors, directed-energy weapons may be cheaper to operate than conventional weapons in certain contexts.^[37]
- Use of high-powered microwave weapons, which are typically used to degrade and damage electronics such as drones, can be hard to attribute to a particular actor.^[38]

Types

Microwave

Some devices are described as microwave weapons; the microwave frequency is commonly defined as being between 300 MHz and 300 GHz (wavelengths of 1 meter to 1 millimeter), which is within the [radiofrequency](#) (RF) range.^[39]

Active Denial System

[Active Denial System](#) is a millimeter wave source that heats the water in a human target's skin and thus causes incapacitating pain. It was developed by the [U.S. Air Force Research Laboratory](#) and [Raytheon](#) for riot-control duty. Though intended to cause severe pain while leaving no lasting damage, concern has been voiced as to whether the system could cause irreversible damage to the eyes. There has yet to be testing for long-term side effects of exposure to the microwave beam. It can also destroy [unshielded electronics](#).^[40]

Vigilant Eagle

[Vigilant Eagle](#) is a ground-based airport defense system that directs high-frequency microwaves towards any projectile that is fired at an aircraft.^[41] It was announced by [Raytheon](#) in 2005, and the effectiveness of its waveforms was reported to have been demonstrated in field tests to be highly effective in defeating [MANPADS](#) missiles.

The system consists of a missile-detecting and tracking subsystem (MDT), a command and control system, and a scanning array. The MDT is a fixed grid of passive infrared (IR) cameras. The command and control system determines the missile launch point. The scanning array projects microwaves that disrupt the surface-to-air missile's guidance system, deflecting it from the aircraft.^[42] Vigilant Eagle was not mentioned on Raytheon's Web site in 2022.

Bofors HPM Blackout

[Bofors HPM Blackout](#) is a high-powered microwave weapon that is said to be able to destroy at short distance a wide variety of [commercial off-the-shelf](#) (COTS) electronic equipment and is purportedly non-lethal.^{[43][44][45]}

EL/M-2080 Green Pine|EL/M-2080 Green P

The [effective radiated power](#) (ERP) of the [EL/M-2080 Green Pine radar](#) makes it a hypothetical candidate for conversion into a directed-energy weapon, by focusing pulses of radar energy on target missiles.^[46] The energy spikes are tailored to enter missiles through antennas or sensor apertures where they can fool guidance systems, scramble computer memories or even burn out sensitive electronic components.^[46]

Active electronically scanned array

[AESA](#) radars mounted on fighter aircraft have been slated as directed energy weapons against missiles, however, a senior US Air Force officer noted: "they aren't particularly suited to create weapons effects on missiles because of limited antenna size, power and field of view".^[47] Potentially lethal effects are produced only inside 100 meters range, and disruptive effects at distances on the order of one kilometer. Moreover, cheap countermeasures can be applied to existing missiles.^[48]

Anti-drone rifle



A Pischal-Pro anti-drone rifle, featured at the Dubai Airshow, 2019

A weapon often described as an "anti-drone rifle" or "anti-drone gun" is a battery-powered electromagnetic pulse weapon held to an operator's shoulder, pointed at a flying target in a way similar to a [rifle](#), and operated. While not a rifle or gun, it is so nicknamed as it is handled in the same way as a personal rifle. The device emits separate electromagnetic pulses to suppress navigation and transmission channels used to operate an [aerial drone](#), terminating the drone's contact with its operator; the out-of-control drone then crashes. The Russian *Stupor* is reported to have a range of two kilometers, covering a 20-degree sector; it also suppresses the drone's cameras. *Stupor* is reported to have been used by Russian forces during the [Russian military intervention in the Syrian civil war](#).^[49]

Both Russia and Ukraine are reported to use these devices during the [2022 Russian invasion of Ukraine](#).^[49] The Ukrainian army are reported to use the Ukrainian KVS G-6, with a 3.5 km range and able to operate continuously for 30 minutes. The manufacturer states that the weapon can disrupt remote control, the transmission of video at 2.4 and 5 GHz, and [GPS](#) and [Glonass satellite navigation](#) signals.^[50] Ukraine has also used the [EDM4S](#) anti drone rifle to shoot down Russian [Eleron-3](#) drones.^[51]

Due to the threat posed by drones in regard to terrorism, several police forces have carried anti-drone guns as part of their equipment. For example, during the policing of the Commonwealth Games in 2018, the Australian [Queensland Police Service](#) carried anti-drone guns with an effective range of 3 km (2 mi).^[52] In Myanmar, police have been equipped with anti-drone guns "ostensibly to defend VIPs".^[53]

Counter-electronics High Power Microwave Advanced Missile Project

The [Counter-electronics High Power Microwave Advanced Missile Project \(CHAMP\)](#) is a joint concept technology demonstration led by the [Air Force Research Laboratory, Directed Energy](#)

[Directorate](#) at [Kirtland Air Force Base](#) to develop an air-launched directed-energy weapon capable of incapacitating or damaging electronic systems^[54] by means of an EMP ([electromagnetic pulse](#)).^[55]

THOR/Mjolnir

The Tactical High-power Operational Responder ([THOR](#)) is a [high-power microwave directed energy weapon](#) developed by the United States [Air Force Research Laboratory](#) (AFRL).

Radio Frequency Directed Energy Weapon (RFDEW)

This UK-developed system was unveiled in May 2024 and uses radio waves to fry the electronic components of its targets, rendering them inoperable. It is capable of engaging multiple targets, including drone swarms, and reportedly costs less than 10 [pence](#) (13 [cents](#)) per shot, making it a cheaper alternative to traditional missile-based air defense systems.^[56]

Laser



Members of the Directed Energy and Electric Weapon Systems Program Office of the [US Navy](#), fire a laser through a beam director on a Kineto Tracking Mount, controlled by a MK-15 [Phalanx Close-In Weapons System](#)

A **laser weapon** is a directed-energy weapon based on [lasers](#).^{[57][58]}

DragonFire

An example of a laser directed-energy weapon is the DragonFire currently being developed by the United Kingdom. It is reportedly in the 50 kW class and is capable of engaging any target within line-of-sight at a currently classified range. It has been tested against drones and mortar rounds and is expected to equip ships, aircraft and ground vehicles from 2027.^[59]

Particle-beam

Particle-beam weapons can use charged or neutral particles, and can be either endoatmospheric or exoatmospheric. [Particle beams](#) as beam weapons are theoretically possible, but practical weapons have not been demonstrated yet. Certain types of particle beams have the advantage of being self-focusing in the atmosphere.

Blooming is also a problem in particle-beam weapons. Energy that would otherwise be focused on the target spreads out and the beam becomes less effective:

- Thermal blooming occurs in both charged and neutral particle beams, and occurs when particles bump into one another under the effects of thermal vibration, or bump into air molecules.
- Electrical blooming occurs only in charged particle beams, as ions of like charge repel one another.

Plasma

Plasma weapons fire a beam, bolt, or [stream](#) of [plasma](#), which is an excited [state of matter](#) consisting of atomic electrons and nuclei, and free electrons if [ionized](#), or other particles if [pinched](#).

The [MARAUDER](#) (*Magnetically Accelerated Ring to Achieve Ultra-high Directed-Energy and Radiation*) used the [Shiva Star](#) project (a high energy capacitor bank which provided the means to test weapons and other devices requiring brief and extremely large amounts of energy) to accelerate a toroid of plasma at a significant percentage of the speed of light.^[60]

The [Russian Federation](#) claims to be developing various plasma weapons.^[61]

Sonic

Long Range Acoustic Device (LRAD)



The LRAD is the round black device on top of the [NYPD](#) police Humvee.

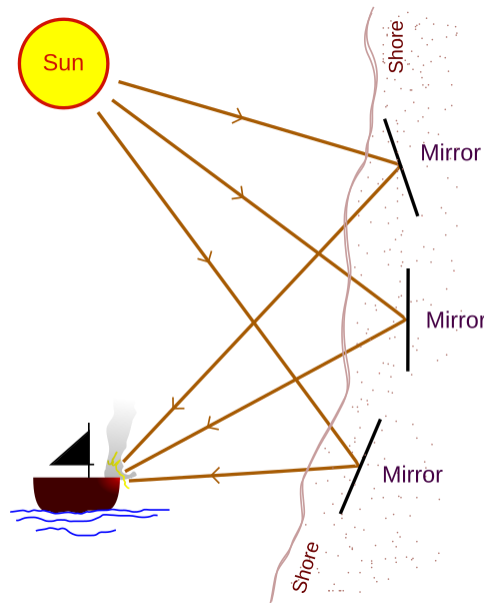
The [Long Range Acoustic Device \(LRAD\)](#) is an [acoustic hailing device](#) developed by [Genasys](#) (formerly LRAD Corporation) to send messages and warning tones over longer distances or at higher volume than normal [loudspeakers](#), and as a non-lethal directed-acoustic-energy weapon. LRAD systems are used for long-range communications in a variety of applications^[62] and as a means of non-lethal, non-projectile crowd control. They are also used on ships as an anti-piracy measure.

According to the manufacturer's specifications, the systems weigh from 15 to 320 pounds (7 to 145 kg) and can emit sound in a 30°- 60° beam at 2.5 kHz.^[63] They range in size from small, portable handheld units which can be strapped to a person's chest, to larger models which require a mount.^[64] The power of the sound beam which LRADs produce is sufficient to penetrate vehicles and buildings while retaining a high degree of fidelity, so that verbal messages can be conveyed clearly in some situations.^[65]

History

Ancient

Mirrors of Archimedes



Archimedes may have used mirrors acting collectively as a [parabolic reflector](#) to burn ships attacking [Syracuse](#).

According to a legend, [Archimedes](#) created a mirror with an adjustable focal length (or more likely, a series of mirrors focused on a common point) to focus sunlight on ships of the [Roman](#) fleet as they invaded [Syracuse](#), setting them on fire.^[66] Historians point out that the earliest accounts of the battle did not mention a "burning mirror", but merely stated that Archimedes's ingenuity combined with a way to hurl fire were relevant to the victory. Some attempts to replicate this feat have had some success; in particular, an experiment by students at [MIT](#) showed that a mirror-based weapon was at least possible, if not necessarily practical.^[67] The hosts of [MythBusters](#) tackled the Mirrors of Archimedes three times (in [episodes 19, 57 and 172](#)) and were never able to make the target ship catch fire, declaring the myth busted three separate times.

20th Century

Robert Watson-Watt

In 1935, the British [Air Ministry](#) asked [Robert Watson-Watt](#) of the [Radio Research Station \(UK\)](#) whether a "death ray" was possible.^{[68][69]} He and colleague [Arnold Wilkins](#) quickly concluded that it

was not feasible, but as a consequence suggested using radio for the detection of aircraft and this started the development of [radar](#) in Britain.^{[70][71]}

The fictional "engine-stopping ray"

Stories in the 1930s and World War II gave rise to the idea of an "engine-stopping ray". They seemed to have arisen from the testing of the television transmitter in [Feldberg](#), Germany. Because electrical noise from car engines would interfere with field strength measurements, sentries would stop all traffic in the vicinity for the twenty minutes or so needed for a test. Reversing the order of events in retelling the story created a "tale" where tourists car engine stopped first and then were approached by a German soldier who told them that they had to wait. The soldier returned a short time later to say that the engine would now work and the tourists drove off. Such stories were circulating in Britain around 1938 and during the war British Intelligence relaunched the myth as a "British engine-stopping ray," trying to spoof the Germans into researching what the British had supposedly invented in an attempt to tie up German scientific resources.^[72]

German World War II experimental weapons

During the early 1940s [Axis](#) engineers developed a sonic cannon that could cause fatal vibrations in its target body. A [methane gas combustion chamber](#) leading to two [parabolic dishes](#) pulse-detonated at roughly 44 [Hz](#). This sound, magnified by the dish reflectors, caused [vertigo](#) and [nausea](#) at 200–400 meters (220–440 yd) by vibrating the [middle ear](#) bones and shaking the [cochlear fluid](#) within the [inner ear](#). At distances of 50–200 meters (160–660 ft), the [sound waves](#) could act on organ tissues and fluids by repeatedly compressing and releasing compressive resistant organs such as the [kidneys](#), [spleen](#), and [liver](#). (It had little detectable effect on malleable organs such as the [heart](#), [stomach](#) and [intestines](#).) [Lung](#) tissue was affected at only the closest ranges as [atmospheric air](#) is highly compressible and only the blood rich [alveoli](#) resist compression. In practice, the [weapon](#) was highly vulnerable to enemy fire. [Rifle](#), [bazooka](#) and [mortar](#) rounds easily deformed the parabolic reflectors, rendering the wave amplification ineffective.^[73]

In the later phases of [World War II](#), [Nazi Germany](#) increasingly put its hopes on research into technologically revolutionary secret weapons, the [Wunderwaffe](#).

Among the directed-energy weapons the Nazis investigated were [X-ray](#) beam weapons developed under Heinz Schmellenmeier, Richard Gans and Fritz Houtermans. They built an electron accelerator called Rheotron to generate hard X-ray [synchrotron](#) beams for the Reichsluftfahrtministerium (RLM). Invented by [Max Steenbeck](#) at [Siemens-Schuckert](#) in the 1930s, these were later called [Betatrons](#) by the Americans. The intent was to pre-ionize ignition in aircraft engines and hence serve as anti-

aircraft DEW and bring planes down into the reach of the flak. The Rheotron was captured by the Americans in Burggrub on April 14, 1945.

Another approach was Ernst Schiebolds 'Röntgenkanone' developed from 1943 in Großostheim near [Aschaffenburg](#). Richert Seifert & Co from Hamburg delivered parts.^[74]

Reported use in Sino-Soviet conflicts

The [Central Intelligence Agency](#) informed [Secretary Henry Kissinger](#) that it had twelve reports of Soviet forces using laser weapons against Chinese forces during the [1969 Sino-Soviet border clashes](#), though [William Colby](#) doubted that they had actually been employed.^[75]

Northern Ireland "squawk box" field trials

In 1973, [New Scientist](#) magazine reported that a sonic weapon known as a "squawk box" underwent successful field trials in Northern Ireland, using soldiers as guinea pigs. The device combined two slightly different frequencies which when heard would be heard as the sum of the two frequencies (ultrasonic) and the difference between the two frequencies (infrasonic) e.g. two directional speakers emitting 16,000 Hz and 16,002 Hz frequencies would produce in the ear two frequencies of 32,002 Hz and 2 Hz. The article states: "The squawk box is highly directional which gives it its appeal. Its effective beam width is so small that it can be directed at individuals in a riot. Other members of a crowd are unaffected, except by panic when they see people fainting, being sick, or running from the scene with their hands over their ears. The virtual inaudibility of the equipment is said to produce a 'spooky' psychological effect."^[76] The UK's [Ministry of Defence](#) denied the existence of such a device. It stated that it did have, however, an "ultra-loud public address system which [...] could be 'used for verbal communication over two miles, or put out a sustained or modulated sound blanket to make conversation, and thus crowd organisation, impossible.'"^{[77][78]}

East German "decomposition" methods



The writer [Jürgen Fuchs](#) described decomposition methods as 'an attack on the human soul'.^[79] He died of a rare form of [leukemia](#) in 1999 which he believed was the result of [radiation poisoning](#). He, and others, suspected he had been targeted with directed X-rays during his imprisonment.^{[80][81]}

In [East Germany](#) in the 1960s, in an effort to avoid international condemnation for arresting and interrogating people for holding politically incorrect views or for performing actions deemed hostile by the state security service, the [Stasi](#), attempted alternative methods of repression which could paralyze people without imprisoning them. One such alternative method was called decomposition (transl. [Zersetzung](#)). In the 1970s and 1980s it became the primary method of repressing domestic "hostile-negative" forces.^[82]

Some of the victims of this method suffered from [cancer](#) and claimed that they had also been targeted with directed [X-rays](#). In addition, when the East German state collapsed, powerful X-ray equipment was found in prisons without there being any apparent reason to justify its presence. In 1999, the modern German state was investigating the possibility that this X-ray equipment was being used as weaponry and that it was a deliberate policy of the Stasi to attempt to give prisoners radiation poisoning, and thereby cancer, through the use of directed X-rays.^[80]

The negative effects of the radiation poisoning and cancer would extend past the period of incarceration. In this manner someone could be debilitated even though they were no longer imprisoned. The historian Mary Fulbrook states,

The subsequent serious illnesses and premature deaths of dissidents such as the novelist Jürgen Fuchs, and the author of the critical analysis of 'The Alternative in Eastern Europe', Rudolf Bahro, have been linked by some to the suspicion of exposure to extraordinarily high and sustained levels of X-rays while waiting for interrogations, and being strapped to unpleasant chairs in small prison cells in front of mysterious closed boxes- boxes that, along with their mysterious apparatus, curiously disappeared after the collapse of the SED (Socialist Unity Party of Germany) system.^[83]

Strategic Defense Initiative

In the 1980s, [U.S. President Ronald Reagan](#) proposed the [Strategic Defense Initiative](#) (SDI) program, which was nicknamed [Star Wars](#). It suggested that lasers, perhaps space-based [X-ray lasers](#), could destroy [ICBMs](#) in flight. Panel discussions on the role of high-power lasers in SDI took place at various laser conferences, during the 1980s, with the participation of noted physicists including [Edward Teller](#).^{[84][85]}

A notable example of a directed energy system which came out of the SDI program is the Neutral Particle Beam Accelerator developed by [Los Alamos National Laboratory](#). This system is officially described (on the Smithsonian Air and Space Museum website^[86]) as a low power neutral particle beam (NPB) accelerator, which was among several directed energy weapons examined by the Strategic Defense Initiative Organization for potential use in missile defense. In July 1989, the accelerator was launched from [White Sands Missile Range](#) as part of the Beam Experiment Aboard Rocket (BEAR) project, reaching an altitude of 200 kilometers (124 miles) and operating successfully in space before being recovered intact after reentry.^[87] The primary objectives of the test were to assess NPB propagation characteristics in space and gauge the effects on spacecraft components.^[88] Despite continued research into NPBs, no known weapon system utilizing this technology has been deployed.^[86]

Though the strategic missile defense concept has continued to the present under the [Missile Defense Agency](#), most of the directed-energy weapon concepts were shelved. However, Boeing has been somewhat successful with the [Boeing YAL-1](#) and [Boeing NC-135](#), the first of which destroyed two missiles in February 2010. Funding has been cut to both of the programs.

Iraq War

During the [Iraq War](#), electromagnetic weapons, including high power microwaves, were used by the U.S. military to disrupt and destroy Iraqi electronic systems and may have been used for crowd control. Types and magnitudes of exposure to electromagnetic fields are unknown.^[89]

Alleged tracking of Space Shuttle *Challenger*

The [Soviet Union](#) invested some effort in the development of [ruby](#) and [carbon dioxide lasers](#) as anti-ballistic missile systems, and later as a tracking and [anti-satellite](#) system. There are reports that the [Terra-3](#) complex at [Sary Shagan](#) was used on several occasions to temporarily "blind" US spy satellites in the IR range.

It has been claimed that the USSR made use of the lasers at the Terra-3 site to target the Space Shuttle [Challenger](#) in 1984.^{[90][91]} At the time, the Soviet Union was concerned that the shuttle was being used as a reconnaissance platform. On 10 October 1984 ([STS-41-G](#)), the Terra-3 tracking laser was allegedly aimed at *Challenger* as it passed over the facility. Early reports claimed that this was responsible for causing "malfunctions on the space shuttle and distress to the crew", and that the United States filed a diplomatic protest about the incident.^{[90][91]} However, this story is comprehensively denied by the crew members of STS-41-G and knowledgeable members of the US intelligence community.^[92] After the end of the [Cold War](#), the Terra-3 facility was found to be a low-power laser testing site with limited satellite tracking capabilities, which is now abandoned and partially disassembled.

Modern 21st-century use

Havana syndrome

Havana syndrome is a disputed medical condition reported by US personnel in [Havana, Cuba](#) and other locations, originally suspected to be caused by [microwave radiation](#).^[93] In January 2022, the Central Intelligence Agency issued an interim assessment concluding that the syndrome is not the result of "a sustained global campaign by a hostile power." Foreign involvement was ruled out in 976 cases of the 1,000 reviewed.^{[94][95]} In February 2022, the State Department released a report by the JASON Advisory Group, which stated that it was highly unlikely that a directed-energy attack had caused the health incidents.^[96] The cause of Havana syndrome remains unknown and controversial.^{[97][98]}

Anti-piracy measures

LRADs are often fitted on commercial and military ships. They have been used on several occasions to repel pirate attacks by sending warnings and by producing intolerable levels of sound. For example, in 2005 the cruise liner *Seabourn Spirit* used a sonic weapon to defend itself from Somali pirates in the Indian ocean.^[99] A few years later, the cruise liner *Spirit of Adventure* also defended itself from Somali pirates by using its LRAD to force them to retreat.^{[100][101]}

Non-lethal weapon capability

The TECOM Technology Symposium in 1997 concluded on [non-lethal weapons](#), "determining the target effects on personnel is the greatest challenge to the testing community", primarily because "the potential of injury and death severely limits human tests".^[102]

Also, "directed-energy weapons that target the central nervous system and cause neurophysiological disorders may violate the [Certain Conventional Weapons Convention](#) of 1980. Weapons that go beyond non-lethal intentions and cause 'superfluous injury or unnecessary suffering' may also violate the [Protocol I](#) to the Geneva Conventions of 1977".^[103]

Some common bio-effects of non-lethal electromagnetic weapons include:

- Difficulty breathing
- [Disorientation](#)
- [Nausea](#)
- [Pain](#)
- [Vertigo](#)
- Other systemic discomfort

Interference with breathing poses the most significant, potentially lethal results.

Light and repetitive visual signals can induce [epileptic](#) seizures. [Vection](#) and [motion sickness](#) can also occur.

Russia has reportedly been using blinding laser weapons during the [Russo-Ukrainian War](#).^[104]

See also

- [Electronic warfare](#)

- Electromagnetic pulse
- Ivan's hammer
- L3Harris Technologies
- Laser applications
- MEDUSA (weapon)

Notes

1. "Daily Telegraph, 12th September 2013" (<https://www.telegraph.co.uk/news/uknews/defence/10303988/Golden-Eye-style-energy-beam-is-developed-by-Nato-scientists.html>) , *Golden Eye-style energy beam is developed by Nato scientists*, Oct. 08, 2013
2. "Milsat Magazine, Satnews Daily, June 24th 2009" (<http://www.satnews.com/story.php?number=1272864526>) , *U.S. Navy Laser Versus UAVs... Laser Wins...*, Oct. 08, 2013
3. *Thaad-ER In Search Of A Mission* (<http://aviationweek.com/defense/thaad-er-search-mission>) – Aviationweek.com, 20 January 2015
4. General, Ryan; Read, 2016·1 Min (December 20, 2016). "The Chinese Military Now Has Laser Weapons" (<https://nextshark.com/the-chinese-military-now-have-laser-weapons/>) . NextShark. Retrieved December 26, 2017.
5. "Drones, lasers, and tanks: China shows off its latest weapons" (<https://www.popsci.com/china-new-weapons-lasers-drones-tanks/>) . *Popular Science*. 18 March 2019.
6. Mizokami, Kyle (January 30, 2017). "New Chinese Microwave Weapon Can Short Out IEDs and Tanks" (<https://www.popularmechanics.com/military/research/news/a24973/chinese-microwave-weapon-short-out-ieds-tanks/>) . *Popular Mechanics*.
7. "How China Is Weaponizing Outer Space" (<https://thediplomat.com/2017/01/how-china-is-weaponizing-outer-space/>) . *thediplomat.com*.
8. Vara, Vasanthi (July 23, 2021). "Laser directed energy weapons likely to receive the most investment in future: Poll" (<https://www.airforce-technology.com/news/laser-directed-energy-weapons-likely-to-receive-the-most-investment-in-future-poll/>) . *airforce-technology.com*.
9. "EDA Studying the Use of Naval Directed Energy Weapons" (<https://www.navalnews.com/naval-news/2019/11/eda-studying-the-use-of-naval-directed-energy-weapons/>) . *navalnews.com*. November 18, 2019.

10. "The French Have Plans For A Constellation Of Laser-Armed Miniature Satellites" (<https://www.thedrive.com/the-war-zone/29152/the-french-have-plans-for-a-constellation-of-laser-armed-miniature-satellites>) . *thedrive.com*. July 26, 2019.
11. "High Energy Laser For Multiple Applications" (<https://cilas.ariane.group/wp-content/uploads/sites/5/2021/05/HELMA-LASER-WEAPON-PRODUCT-LINE.pdf>) (PDF). *cilas.ariane.com*. February 2021.
12. "Dragonfire laser turret unveiled at DSEI 2017 – MBDA" (<http://www.mbda-systems.com/press-releases/dragonfire-laser-turret-unveiled-dsei-2017/>) . *MBDA*. Retrieved 2017-10-21.
13. "Dragonfire, a guide to the new British laser weapon" (<https://ukdefencejournal.org.uk/dragonfire-guide-new-british-laser-weapon/>) . *UK Defence Journal*. 2017-09-18. Retrieved 2017-10-21.
14. Egorov, Boris (July 12, 2017). "A farewell to traditional arms: Russia develops weapons for the future" (https://www.rbth.com/defence/2017/07/12/a-farewell-to-traditional-arms-russia-develops-weapons-for-the-future_801080) . *rbth.com*.
15. "Russia's new MiG-35 fighter jet to use laser weapons" (https://web.archive.org/web/20200814053009/https://www.pravdareport.com/news/russia/136730-mig_35_laser/) . *PravdaReport*. January 27, 2017. Archived from the original (https://www.pravdareport.com/news/russia/136730-mig_35_laser/) on August 14, 2020. Retrieved July 18, 2020.
16. Sudakov, Dmitry (August 3, 2016). "Russia's combat laser weapons declassified" (https://web.archive.org/web/20200718053817/https://www.pravdareport.com/russia/135198-russia_laser_weapons/) . *PravdaReport*. Archived from the original (https://www.pravdareport.com/russia/135198-russia_laser_weapons/) on July 18, 2020. Retrieved July 18, 2020.
17. "KALI: India's weapon to destroy any uninvited missiles and aircrafts [*sic*]" (<https://www.indiatoday.in/education-today/gk-current-affairs/story/indias-top-secret-weapon-264111-2015-09-21>) . *India Today*. September 21, 2015.
18. "Future technologies must be propelled by power of today's youth: DRDO chairman" (<https://www.onmanorama.com/news/nation/2019/08/15/drdo-chief-amca-india-defence-advancements.html>) . *OnManorama*. Retrieved 2020-09-15.
19. Pandit, Rajat (September 14, 2020). "DRDO plans Star Wars-style weapons for battles of future" (<https://timesofindia.indiatimes.com/india/drdo-plans-star-wars-style-weapons-for-battles-of-future/articleshow/78096712.cms>) . *The Times of India*. Retrieved 2020-09-15.

20. Pubby, Manu (2025-04-15). "ET Graphics: A decade in the making, India's first high-powered laser weapon" (<https://economictimes.indiatimes.com/news/defence/et-graphics-a-decade-in-the-making-indias-first-high-powered-laser-weapon/articleshow/120289633.cms?from=mdr>) . *The Economic Times*. ISSN 0013-0389 (<https://search.worldcat.org/issn/0013-0389>) . Retrieved 2025-04-15.
21. "Indian Army uses new DRDO laser to neutralise Chinese drone near LoC" (<https://economictimes.indiatimes.com/news/defence/indian-army-uses-new-drdo-laser-to-neutralise-chinese-drone-near-loc/articleshow/120254260.cms?from=mdr>) . *The Economic Times*. 2025-04-13. ISSN 0013-0389 (<https://search.worldcat.org/issn/0013-0389>) . Retrieved 2025-04-15.
22. "What is Israel's Iron Beam?" (<https://www.economist.com/the-economist-explains/2023/11/13/what-is-israels-iron-beam>) . *The Economist*. Nov 13, 2023.
23. "Israeli-Made High-Energy Laser Makes Debut" (<https://www.nationaldefensemagazine.org/articles/2023/3/21/israeli-made-high-energy-laser-makes-debut>) . *National Defense Magazine*.
24. "Israel deployed Iron Beam laser system on Gaza front, Rafael chairman reveals" (<https://www.calcalistech.com/ctechnews/article/hyt7300ft6>) . *CTech*. 20 January 2024.
25. "Iran starts producing laser weapons for air defense" (<https://news.am/eng/news/544830.html>) . *news.am*.
26. "Iran achieves Laser Weapon System's deflection technology" (<https://web.archive.org/web/20230421232452/https://www.worldbulletin.net/middle-east/iran-achieves-laser-weapon-systems-deflection-technology-h121001.html>) . *worldbulletin.net*/. Archived from the original on April 21, 2023.
27. "Iran is Producing Laser Air Defense System" (<https://www.islamtimes.org/en/news/827708/iran-is-producing-laser-air-defense-system>) . *Islam Times*. November 16, 2019.
28. "IRGC Navy develops anti-laser weapon" (<https://www.tehrantimes.com/news/433633/IRGC-Navy-develops-anti-laser-weapon>) . *Tehran Times*. March 3, 2019.
29. "Turkey's laser weapon ARMOL passes acceptance tests" (<https://www.dailysabah.com/defense/2019/09/30/turkeys-laser-weapon-armol-passes-acceptance-tests>) . *DailySabah*. 30 September 2019. Retrieved 2020-02-08.
30. "Janes | Latest defence and security news" (<https://www.janes.com/defence-news>) . *Janes.com*.
31. "Turkey's laser gun passes acceptance tests" (<https://www.aa.com.tr/en/economy/turkeys-laser-gun-passes-acceptance-tests/1597850>) . *aa.com.tr*. Retrieved 2020-02-08.

32. "Is Turkey the first country to shoot down a drone with a laser?" (<https://ahvalnews.com/libya-turkey/turkey-first-country-shoot-down-drone-laser>) . *Ahval*. 3 September 2019. Retrieved 2020-02-08.
33. "Navy's new laser weapon: Hype or reality?" (<https://thebulletin.org/2015/05/navys-new-laser-weapon-hype-or-reality/>) . May 18, 2015.
34. "Full Page Reload" (<https://spectrum.ieee.org/no-quick-laser-missile-defense>) . *IEEE Spectrum: Technology, Engineering, and Science News*. 27 September 2017.
35. "Defence IQ talks to Dr Palíšek about Directed Energy Weapon systems" (<http://www.defenceiq.com/army-and-land-forces/articles/we-talk-to-dr-pali-ek-about-directed-energy-system/>) , *Defence iQ*, Nov. 20, 2012
36. Spectrum Tutorial (<http://cmb.physics.wisc.edu/tutorial/spectrum.html>) Archived (<https://web.archive.org/web/20130531032118/http://cmb.physics.wisc.edu/tutorial/spectrum.html>) 2013-05-31 at the [Wayback Machine](#), University of Wisconsin Electromagnetic Spectrum Tutorial, accessed 22/06/2013
37. "US Navy Laser Weapon Fires At \$1 Per Shot" (https://www.defenseworld.net/news/11684/US_Navy_Laser_Weapon_Fires_at__1_Per_Shot#.XSkSzutKhE) . *Defenseworld.net*. Retrieved 12 July 2019.
38. Grand-Clément, Sarah (12 May 2022). "Directed energy weapons: a new look at an 'old' technology" (<https://unidir.org/directed-energy-weapons-a-new-look-at-an-old-technology>) . *United Nations Institute for Disarmament Research*. Retrieved 9 January 2024.
39. RF vs Microwave Freq range (<http://wifiinschools.org.uk/15.html>) , microwaves and radio waves
40. "The Pentagon's Ray Gun" (<https://www.cbsnews.com/news/the-pentagons-ray-gun/>) . *CBS News*. 2008-06-01. Retrieved 2009-03-30.
41. "Raytheon focuses on non-lethal weapons", Andrew Johnson, *The Arizona Republic*, 09-17-2009.
42. Raytheon Vigilant Eagle datasheet (http://www.raytheon.com/capabilities/rtnwcm/groups/rms/documents/content/rtn_rms_ps_vigilanteagle_datas.pdf)
43. "Home" (https://web.archive.org/web/20100825185029/http://www.baesystems.com/ProductServices/BAE_GCSW_hpm_blackout.html) . *BAE Systems | International*. Archived from the original (<https://www.baesystems.com/en/home>) on August 25, 2010.

44. Magnus Karlsson (2009). "Bofors HPM Blackout". *Artilleri-Tidskrift* (2–2009): s. s 12–15. Retrieved 2010-01-04.
45. "Google" (https://www.google.com/#hl=en&cp=19&gs_id=a&xhr=t&q=Bofors+HPM+Blackout&pf=p&sclient=psy-ab&site=&source=hp&pbx=1&oq=Bofors+HPM+Blackout&aq=0&aqi=g1&aql=&gs_sm=&gs_upl=&bav=on.2,or.r_gc.r_pw.,cf.osb&fp=d8c3d6158c86e07e&biw=1680&bih=916) . *google.com*.
46. Fulghum, David A. (2005-12-17). "Israel tests improved Arrow interceptor" (http://www.aviationweek.com/aw/generic/story_generic.jsp?channel=awst&id=news/12195p3.xml&headline=Israel%20Tests%20Improved%20Arrow%20Interceptor) . *Aviation Week & Space Technology*. Retrieved 2009-08-19.
47. David A. Fulghum & Douglas Barrie (2005-09-06). "Radar Becomes A Weapon" (<http://omega.twoday.net/stories/955265/>) . *Aviation Week & Space Technology*. Retrieved 2014-05-16.
48. Colonel of Aviation Grigoriy "Grisha" Medved (ret'd) (2008-04-13). "Grisha's Radar fry-off" (<http://www.ausairpower.net/APA-NOTAM-130408-1.html>) . *Air Power Australia*. Retrieved 2014-05-16.
49. "Russia Uses Stupor Technology To Ward Off Ukrainian Drone Attacks" (<https://voi.id/en/technology/193250/russia-uses-stupor-technology-to-ward-off-ukrainian-drone-attacks>) . *VOI - Waktunya Merevolusi Pemberitaan*. Russia Today. 22 July 2022.
50. Frahan, Alain Henry de (6 July 2022). "Defense News - Russian army confirms use of Stupor anti-drone rifle in Ukraine" (https://www.armyrecognition.com/defense_news_july_2022_global_security_army_industry/russian_army_confirms_use_of_stupor_anti-drone_rifle_in_ukraine.html) . *TASS – via armyrecognition.com*.
51. Trinko, Myroslav. "The Ukrainian armed forces used the EDM4S Sky Wiper anti-drone cannon to shoot down the Russian Eleron-3 reconnaissance UAV" (<https://gagadget.com/en/war/173398-the-ukrainian-armed-forces-used-the-edm4s-sky-wiper-anti-drone-cannon-to-shoot-down-the-russian-eleron-3-reconnaissance/>) . *gagadget.com*. Archived (<https://web.archive.org/web/20221006120053/https://gagadget.com/en/war/173398-the-ukrainian-armed-forces-used-the-edm4s-sky-wiper-anti-drone-cannon-to-shoot-down-the-russian-eleron-3-reconnaissance/>) from the original on 6 October 2022. Retrieved 6 October 2022.
52. Farmer, Clare; Evans, Richard; Goldsworthy, Terry (2023). *Policing & Firearms: New Perspectives and Insights*. Springer. p. 135. ISBN 978-3-031-13013-7.

53. Campbell, Charlie (23 March 2023). "The Anti-Drone Arms Race: Inside the Fight to Protect the World's Skies" (<https://time.com/6265108/drone-trd-singapore-unmanned-aerial-vehicle/>) . *TIME magazine*. Retrieved 12 April 2023.
54. Fulghum, David. "Leave Them Sitting In Silence, In The Dark" (<https://web.archive.org/web/20100321164415/http://www.aviationweek.com/aw/blogs/defense/index.jsp?plckController=Blog>) . Aviation Week. Archived from the original (<http://www.aviationweek.com/aw/blogs/defense/index.jsp?plckController=Blog&plckScript=blogScript&plckElementId=blogDest&plckBlogPage=BlogViewPost&plckPostId=Blog%3A27ec4a53-dcc8-42d0-bd3a-01329aef79a7Post%3A347da0db-c427-4928-85ff-da01662523fe>) on March 21, 2010. Retrieved 2009-03-04.
55. Lewis, Brandon. "Raytheon EMP weapon tested by Boeing, USAF Research Lab" (<http://mil-embedded.com/news/raytheon-emp-missile-tested-by-boeing-usaf-research-lab/>) . *Military Embedded Systems*. Retrieved 8 December 2017.
56. "Cutting-edge drone killer radio wave weapon developing at pace" (<https://www.gov.uk/government/news/cutting-edge-drone-killer-radio-wave-weapon-developing-at-pace>) . GOV.UK. 16 May 2024. Retrieved 17 May 2024.
57. Drollette, Dan (2015-05-18). "Navy's new laser weapon: Hype or reality?" (<https://thebulletin.org/2015/05/navys-new-laser-weapon-hype-or-reality/#post-heading>) . *Bulletin of the Atomic Scientists*. Retrieved 2025-05-17.
58. Weise, Th.H.G.G.; Jung, M.; Langhans, D.; Gowin, M. (2004). "Overview of directed energy weapon developments". *2004 12th Symposium on Electromagnetic Launch Technology, 2004*. IEEE. pp. 483–489. doi:10.1109/ELT.2004.1398128 (<https://doi.org/10.1109%2FELT.2004.1398128>) . ISBN 978-0-7803-8290-9.
59. "Dragonfire, a guide to the new British laser weapon" (<https://ukdefencejournal.org.uk/dragonfire-guide-new-british-laser-weapon/>) . *UK Defence Journal*. 18 September 2017. Retrieved 22 May 2024.
60. Degnan, J. H.; Peterkin, Jr; Baca, G. P.; Beason, J. D.; Bell, D. E.; Dearborn, M. E.; Dietz, D.; Douglas, M. R.; Englert, S. E.; Englert, T. J.; Hackett, K. E.; Holmes, J. H.; Hussey, T. W.; Kiuttu, G. F.; Lehr, F. M.; Marklin, G. J.; Mullins, B. W.; Price, D. W.; Roderick, N. F.; Ruden, E. L.; Sovinec, C. R.; Turchi, P. J.; Bird, G.; Coffey, S. K.; Seiler, S. W.; Chen, Y. G.; Gale, D.; Graham, J. D.; Scott, M.; Sommars, W. (August 1993). "Compact toroid formation, compression, and acceleration". *Physics of Fluids B*. **5** (8): 2938–2958. Bibcode:1993PhFIB...5.2938D (<https://ui.adsabs.harvard.edu/abs/1993PhFIB...5.2938D>) . doi:10.1063/1.860681 (<https://doi.org/10.1063%2F1.860681>) . OSTI 7369133 (<https://www.osti.gov/biblio/7369133>) .

61. "Russia is developing laser, electromagnetic and plasma weapons" (<http://www.independent.co.uk/news/world/europe/russia-laser-electromagnetic-plasma-weapons-military-kremlin-a7540716.html>) . *The Independent*. January 22, 2017.
62. "Applications – LRAD Corporation website" (<https://web.archive.org/web/20170310075013/https://www.lradx.com/application/>) . Archived from the original (<http://www.lradx.com/application/>) on 2017-03-10. Retrieved 2016-08-07.
63. Corbett, Peter (2009). *A Modern Plague of Pirates* (<https://books.google.com/books?id=E0kUYUOtG0AC&pg=PA65>) . Captain Peter Corbett. p. 65. ISBN 978-0-9562107-0-8.
64. Peskoe-Yang, Lynne (17 June 2020). "How to Dodge the Sonic Weapon Used by Police" (<http://www.popularmechanics.com/military/weapons/a32892398/what-is-lrad-sonic-weapon-pro-tests/>) . *Popular Mechanics*. Retrieved 18 September 2021.
65. "LRAD 100X" (https://www.darley.com/documents/equipment/lrad/LRAD_Datasheet_100X.pdf) (PDF). *darley.com*. Retrieved 18 September 2021.
66. Bill Sweetman. "Directed-Energy Weapons: No Longer Science Fiction" (http://aviationweek.com/defense/directed-energy-weapons-no-longer-science-fiction#slide-0-field_images-1341101) *Aviation Week & Space Technology*, 2015. Archive (<https://web.archive.org/web/20150810084543/http://aviationweek.com/defense/directed-energy-weapons-no-longer-science-fiction>)
67. "2.009 Archimedes Death Ray" (http://web.mit.edu/2.009/www/lectures/10_ArchimedesResult.html) . *web.mit.edu*.
68. Sim, Philip (2014-05-15). "The pioneer who went under the radar" (<https://www.bbc.com/news/uk-scotland-tayside-central-27393558>) . Retrieved 2019-11-22.
69. "Robert Watson-Watt: Biography on Undiscovered Scotland" (<https://www.undiscoveredscotland.co.uk/usbiography/w/robertwatsonwatt.html>) . *undiscoveredscotland.co.uk*. Retrieved 2019-11-22.
70. Harford, Tim (2017-10-09). "How the search for a 'death ray' led to radar" (<https://www.bbc.com/news/business-41188464>) . Retrieved 2019-11-22.
71. "Robert Watson-Watt biography - Science Hall of Fame - National Library of Scotland" (<https://digital.nls.uk/scientists/biographies/robert-watson-watt/>) . *digital.nls.uk*. Retrieved 2019-11-22.
72. Jones, R.V. (1978). *Most Secret War: British Scientific Intelligence 1939–1945*. Coronet. pp. 84, 124. ISBN 0-340-24169-1.

73. Martin O'Collins, director (21 February 2006). "Weird Weapons: The Axis". *Modern Marvels*. Season 12. Episode 8. The History Channel.
74. "Forschungsstätte für Hitlers "Todesstrahlen" " (<http://www.main-netz.de/nachrichten/region/aschaffenburg/aschaffenburg-land/land/art3986,883119>) . Main-netz.de. 2009-08-19. Retrieved 2012-06-12.
75. Colby, William E. (October 29, 1974). *Reports of Use of Laser Weapons By The Soviets Against the Chinese* (<https://www.cia.gov/readingroom/docs/CIA-RDP80M01048A000800160004-5.pdf>) (PDF) (Report). Central Intelligence Agency. CIA-RDP80M01048A000800160004-5. Archived (<https://web.archive.org/web/20170123042941/https://www.cia.gov/library/readingroom/docs/CIA-RDP80M01048A000800160004-5.pdf>) (PDF) from the original on January 23, 2017.
76. "Army tests new riot weapon" (<https://books.google.com/books?id=IHnPv1wTBKIC>) . *New Scientist*: 684. 20 September 1973. Retrieved 18 September 2021.
77. Rodwell, Robert (27 September 1973). "How dangerous is the Army's squawk box?" (<https://books.google.com/books?id=rl-cTbV9O5AC>) . *New Scientist*: 730. Retrieved 18 September 2021.
78. Altmann, Jurgen (2001). "Acoustic Weapons - A Prospective Assessment" (<https://scienceandglobalsecurity.org/archive/sgs09altmann.pdf>) (PDF). *Science & Global Security*. **9** (3): 170. Bibcode:2001S&GS....9..165A (<https://ui.adsabs.harvard.edu/abs/2001S&GS....9..165A>) . doi:10.1080/08929880108426495 (<https://doi.org/10.1080%2F08929880108426495>) . S2CID 31795453 (<https://api.semanticscholar.org/CorpusID:31795453>) .
79. Tierney, Dominic (13 September 2020). "How Putin Got Into America's Mind" (<https://www.theatlantic.com/ideas/archive/2020/09/how-putin-got-into-americas-mind/616330/>) . *The Atlantic*. Retrieved 27 September 2021.
80. Stiasny, Terry. "World: Europe Dissidents say Stasi gave them cancer" (<http://news.bbc.co.uk/1/hi/world/europe/352461.stm>) . *BBC*. Retrieved 27 September 2021.
81. Wensierski, Peter (16 May 1999). "In Kopfhöhe ausgerichtet" (<https://www.spiegel.de/politik/in-kopfhoehe-ausgerichtet-a-5f9391c7-0002-0001-0000-000013395385?context=issue>) . *Der Spiegel*. Retrieved 27 September 2021.
82. Dennis, Mike (2003). "Tackling the enemy- quiet repression and preventive decomposition". *The Stasi: Myth and Reality*. Pearson Education Limited. p. 112. ISBN 0-582-41422-9.
83. Fulbrook, Mary (2008). *The People's State: East German Society from Hitler to Honecker*. New Haven: Yale University Press. p. 245. ISBN 978-0-300-14424-6.

84. Wang, C. P. (Ed.), *Proceedings of the International Conference on Lasers '85* (STS, McLean, Va, 1986).
85. Duarte, F. J. (Ed.), *Proceedings of the International Conference on Lasers '87* (STS, McLean, Va, 1988).
86. "Neutral Particle Beam Accelerator, Beam Experiment Aboard Rocket | National Air and Space Museum" (https://airandspace.si.edu/collection-objects/neutral-particle-beam-accelerator-beam-experiment-aboard-rocket/nasm_A20070004000) . *airandspace.si.edu*. Retrieved 2023-03-05.
87. P. G. O'Shea; T. A. Butler; M. T. Lynch; K. F. McKenna; et al. "A Linear Accelerator in Space – The Beam Experiment Aboard Rocket" (<https://accelconf.web.cern.ch/l90/papers/th454.pdf>) (PDF). *Proceedings of the Linear Accelerator Conference 1990, Los Alamos National Laboratory*.
88. "Ground-breaking experiment artifact now at the Bradbury" (<https://www.lanl.gov/museum/news/newsletter/2017/2017-01/beam-model.php>) . *www.lanl.gov*. Retrieved 2023-03-05.
89. U.S. Senate – Committee on Veterans Affairs: Hearings – Gulf War Illnesses; Testimony to the Senate Veterans Affairs Committee; Meryl Nass, MD, Director of Pulmonary Rehabilitation, Mount Desert Island Hospital Bar Harbor, Maine; September 25, 2007 [1] (https://web.archive.org/web/20071103025251/http://www.senate.gov/~veterans/public/index.cfm?pageid=16&release_id=11326&sub_release_id=11373&view=all)
90. Kononenko, Boris. "Silent Space Is Being Monitored" (https://web.archive.org/web/20111210114952/http://www.fas.org/news/russia/1996/druma189_s96005.htm) . Archived from the original (https://fas.org/news/russia/1996/druma189_s96005.htm) on 10 December 2011. Retrieved 21 July 2011.
91. Zaloga, Steven. "RED STAR WARS" (<http://www.oook.info/dyson/sdi.html>) . Retrieved 21 July 2011.
92. "STS-41-G" (<https://web.archive.org/web/20120620020803/http://www.astronautix.com/flights/sts41g.htm>) . Astronautix.com. Archived from the original (<http://www.astronautix.com/flights/sts41g.htm>) on 2012-06-20. Retrieved 2012-06-12.
93. Broad, William J. (September 1, 2018). "Microwave Weapons Are Prime Suspect in Ills of U.S. Embassy Workers" (<https://www.nytimes.com/2018/09/01/science/sonic-attack-cuba-microwave.html>) . *The New York Times*. Archived (<https://web.archive.org/web/20200513141918/https://www.nytimes.com/2018/09/01/science/sonic-attack-cuba-microwave.html>) from the original on May 13, 2020. Retrieved September 2, 2018.

94. Barnes, Julian E. (January 20, 2022). "Most 'Havana Syndrome' Cases Unlikely Caused by Foreign Power, C.I.A. Says" (<https://www.nytimes.com/2022/01/20/us/politics/havana-syndrome-cia-report.html>) . *The New York Times*. Archived (<https://web.archive.org/web/2022012905959/https://www.nytimes.com/2022/01/20/us/politics/havana-syndrome-cia-report.html>) from the original on January 29, 2022. Retrieved January 21, 2022.
95. "CIA says 'Havana Syndrome' not result of sustained campaign by hostile power" (<https://www.nbcnews.com/politics/national-security/cia-says-havana-syndrome-not-result-sustained-global-campaign-hostile-rcna12838>) . NBC News. January 20, 2022. Archived (<https://web.archive.org/web/20220128160228/https://www.nbcnews.com/politics/national-security/cia-says-havana-syndrome-not-result-sustained-global-campaign-hostile-rcna12838>) from the original on January 28, 2022. Retrieved January 20, 2022.
96. "An Analysis of Data and Hypotheses Related to the Embassy Incidents" (https://www.state.gov/wp-content/uploads/2022/02/JASON-Study-Revised_10-February-2022-Redacted_V1.1.pdf) (PDF). *state.gov*. United States Department of State. February 10, 2022. Archived (https://web.archive.org/web/20221014084219/https://www.state.gov/wp-content/uploads/2022/02/JASON-Study-Revised_10-February-2022-Redacted_V1.1.pdf) (PDF) from the original on October 14, 2022. Retrieved October 19, 2022.
97. Asadi-Pooya AA (December 2023). "Havana syndrome: a scoping review of the existing literature". *Rev Environ Health* (Review). **38** (4): 655–661. Bibcode:2023RvEH...38..655A (<https://ui.adsabs.harvard.edu/abs/2023RvEH...38..655A>) . doi:10.1515/reveh-2021-0182 (<https://doi.org/10.1515%2Freveh-2021-0182>) . PMID 35962646 (<https://pubmed.ncbi.nlm.nih.gov/35962646>) .
98. Connolly, Matthew; Hawkshaw, Mary J.; Sataloff, Robert T. (2024-07-01). "Havana syndrome: Overview for otolaryngologists" (<https://www.sciencedirect.com/science/article/pii/S0196070924001182>) . *American Journal of Otolaryngology*. **45** (4) 104332. doi:10.1016/j.amjoto.2024.104332 (<https://doi.org/10.1016%2Fj.amjoto.2024.104332>) . ISSN 0196-0709 (<https://search.worldcat.org/issn/0196-0709>) . PMID 38663328 (<https://pubmed.ncbi.nlm.nih.gov/38663328>) .

99. Smith, David (6 November 2005). "Pirates shoot at Britons' cruise liner" (<https://www.theguardian.com/travel/2005/nov/06/travelnews.uknews.theobserver>) . *The Guardian*. eISSN 1756-3224 (<https://search.worldcat.org/issn/1756-3224>) . ISSN 0261-3077 (<https://search.worldcat.org/issn/0261-3077>) . LCCN 60623878 (<https://lccn.loc.gov/60623878>) . Archived (<https://web.archive.org/web/20210812204311/https://www.theguardian.com/travel/2005/nov/06/travelnews.uknews.theobserver>) from the original on 12 August 2021. Retrieved 8 March 2022. "The ship's crew triggered a sonic weapon, which sent out ear-splitting bangs to repel the pirates. The Spirit escaped with minor damage and slight injuries to one crew member caused by shrapnel."
100. Casley-Maslen, Stuart (24 March 2014). *Weapons under International Human Rights Law*. Cambridge: Cambridge University Press. p. 154. ISBN 978-1-107-02787-9. LCCN 2013028333 (<https://lccn.loc.gov/2013028333>) . OCLC 905144659 (<https://search.worldcat.org/oclc/905144659>) . OL 26182034M (<https://openlibrary.org/books/OL26182034M>) .
101. Giannangeli, Marco; Jeory, Ted (16 January 2011). "Pirate raid on cruise ship foiled by 'blast' " (<https://www.express.co.uk/news/world/223428/Pirate-raid-on-cruise-ship-foiled-by-blast>) . *The Daily Express*. OCLC 173337077 (<https://search.worldcat.org/oclc/173337077>) . Archived (<https://web.archive.org/web/20210918111808/https://www.express.co.uk/news/world/223428/Pirate-raid-on-cruise-ship-foiled-by-blast>) from the original on 18 September 2021. Retrieved 8 March 2022. "PIRATES were kept away from the British cruise ship Spirit of Adventure by a loud sonic boom device deployed to deafen them, sources revealed last night."
102. John M., Kenny (22 March 2000). *Human Effects Advisory Panel Program* (<https://web.archive.org/web/20041114161030/http://www.dtic.mil/ndia/nld4/kenny.pdf>) (PDF) (Technical report). NDIA. Archived from the original (<http://www.dtic.mil/ndia/nld4/kenny.pdf>) (PDF) on 14 November 2004. Retrieved 8 March 2022.
103. Herbert, Dennis B. (1 March 1991). "Non-Lethal Weaponry: From Tactical to Strategic Applications" (<https://ndupress.ndu.edu/portals/68/Documents/jfq/jfq-21.pdf>) (PDF). *Joint Force Quarterly* (21). National Strategic Studies | National Defense University: 87–91. ISSN 1070-0692 (<https://search.worldcat.org/issn/1070-0692>) . LCCN 93659134 (<https://lccn.loc.gov/93659134>) . OCLC 67048740 (<https://search.worldcat.org/oclc/67048740>) . Archived (<https://web.archive.org/web/20220201093237/https://ndupress.ndu.edu/portals/68/Documents/jfq/jfq-21.pdf>) (PDF) from the original on 1 February 2022. Retrieved 8 March 2022.

104. Ponomarenko, Illia (2 October 2018). "Another blinding laser attack on Ukrainian soldier reported in Donbas war zone" (<https://www.kyivpost.com/ukraine-politics/another-blinding-laser-attack-on-ukrainian-soldier-reported-in-donbas-war-zone.html>) . *KyivPost*. ISSN 1563-6429 (<https://search.worldcat.org/issn/1563-6429>) . LCCN sn97032040 (<https://lccn.loc.gov/sn97032040>) . OCLC 960875078 (<https://search.worldcat.org/oclc/960875078>) . Archived (<http://web.archive.org/web/20211113120609/https://www.kyivpost.com/ukraine-politics/another-blinding-laser-attack-on-ukrainian-soldier-reported-in-donbas-war-zone.html>) from the original on 13 November 2021. Retrieved 2 March 2022. "A Ukrainian Border Guards serviceman deployed in Ukraine's eastern Donbas war zone was reported to have sustained a severe eye injury in what Ukrainian commanders said was another use of prohibited blinding laser weapons by Russian-backed forces in warfare. The incident occurred on the afternoon of Oct. 1 at an observation point close to the front line near the city of Maryinka, a Ukrainian-controlled settlement next to the Kremlin-occupied part of Donetsk Oblast, some 570 kilometers southeast of Kyiv, according to the Ukrainian State Border Service."

References

- *The E-Bomb: How America's New Directed Energy Weapons Will Change the Way Future Wars Will Be Fought*. Doug Beason (2005). ISBN 0-306-81402-1.
- US claims that China has used high-energy lasers to interfere with US satellites (https://web.archive.org/web/20061022123527/http://www4.janes.com/subscribe/jdw/doc_view.jsp?K2DocKey=/content1/janesdata/mags/jdw/history/jdw2006/jdw30761.htm@current&Prod_Name=JDW&QueryText=) : *Jane's Defence Weekly*, 18 October 2006
- China jamming test sparks U.S. satellite concerns (https://www.usatoday.com/tech/news/2006-10-05-satellite-laser_x.htm) : *USA Today*
- Beijing secretly fires lasers to disable US satellites (<https://web.archive.org/web/20061006232452/http://www.telegraph.co.uk/news/main.jhtml?xml=/news/2006/09/26/wchina226.xml>) : *The Daily Telegraph*
- China Attempted To Blind U.S. Satellites With Laser (<http://www.defensenews.com/story.php?F=2121111&C=america>) : *Defense News*
- China Has Not Attacked US Satellites Says DoD (<http://www.upi.com/SecurityTerrorism/view.php?StoryID=20061025-120611-1464r>) : United Press International
- "China Has Not Attacked US Satellites Says DoD" (http://www.spacedaily.com/reports/China_Has_Not_Attacked_US_Satellites_Says_DoD_999.html) : *Space Daily*

- Gertz, Bill (July 21, 2011). "Report: China building electromagnetic pulse weapons for use against U.S. carriers" (<http://www.washingtontimes.com/news/2011/jul/21/beijing-develops-radiation-weapons/>) . *The Washington Times*. Retrieved April 29, 2012.
- Hambling, David (October 10, 2008). "Army Orders Pain Ray Trucks; New Report Shows 'Potential for Death' " (<https://www.wired.com/dangerroom/2008/10/army-ordering-p/>) . *Wired*. Retrieved April 29, 2012.
- Beckhusen, Robert (April 1, 2013). "Air Force Wants New Energy Weapons to Cause Non-Lethal 'Bioeffects' " (<https://www.wired.com/dangerroom/2013/04/air-force-directed-energy/>) . *Wired*. Retrieved April 1, 2013.

External links

- Airpower Australia (<http://www.ausairpower.net/dew-ebomb.html>)
- Applied Energetics – Photonic and high-voltage energetics (formerly Ionatron) (<https://web.archive.org/web/20120303155201/http://appliedenergetics.com/>)
- *Wired* (AP) article on weapons deployment in Iraq, Active Denial System and Stunstrike (<http://archive.wired.com/science/discoveries/news/2005/07/68152>) , July 10, 2005
- Boeing Tests Laser-Mounted Humvee as IED Hunter (https://web.archive.org/web/20071115082409/http://www.popularmechanics.com/technology/military_law/4231116.html) , November 13, 2007
- *WSTIAC Quarterly*, Vol. 7, No. 1 – "Directed Energy Weapons" (https://www.dsiac.org/sites/www.dsiac.org/files/legacy_journal/WSTV7N1.pdf) Archived (https://web.archive.org/web/20161007031430/https://www.dsiac.org/sites/www.dsiac.org/files/legacy_journal/WSTV7N1.pdf) 2016-10-07 at the [Wayback Machine](#)
- Ogonek Report on '21st Century Weapons' (<https://web.archive.org/web/20160304031702/http://fas.org/news/russia/1995/tac95060.htm>)
- "How 'Revolutionary' Is CHAMP, New Air Force Microwave Weapon?" (<https://web.archive.org/web/20130120090619/http://defense.aol.com/2012/11/28/how-revolutionary-is-champ-new-air-force-microwave-weapon/>) , November 28, 2012 by David Axe

